Soils, Resilience and State-and-Transition Models

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Objectives:

(1) Illustrate how two different types of soil properties contribute to resilience through their direct and indirect effects on ecosystem processes, and through feedbacks with plants

(2) Discuss how this information can be used to guide the sampling of dynamic soil properties

Resilience (see Bestelmeyer talk #1):

- *Engineering resilience*: ***how quickly*** a system returns to its previous status (e.g., within a state)
- *Ecological resilience*: capacity of a system to absorb a disturbance without fundamental changes to its characteristic processes and feedbacks (i.e., ***whether*** a system returns to (or maintains) its previous status). Can include both resistance to change *and* capacity to recover.

SpotTheDifference.com

Explorer Game - Brown Level - Tulips

Find 4 differences. ☐ ☐ ☐ ☐

Give up

SpotTheDifference.com

Explorer Game - Brown Level - **States**

Find 4 differences. ☐ ☐ ☐ ☐

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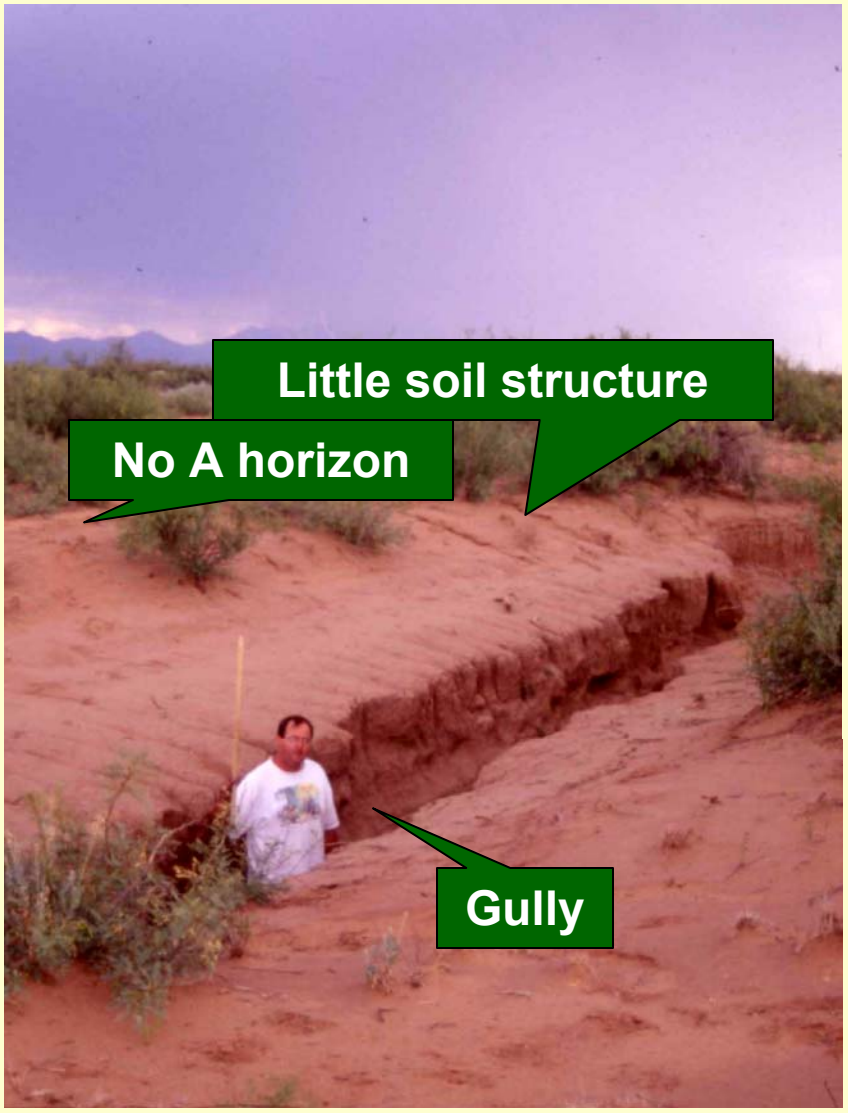
Explorer Game - Brown Level - States



Find 4 differences.

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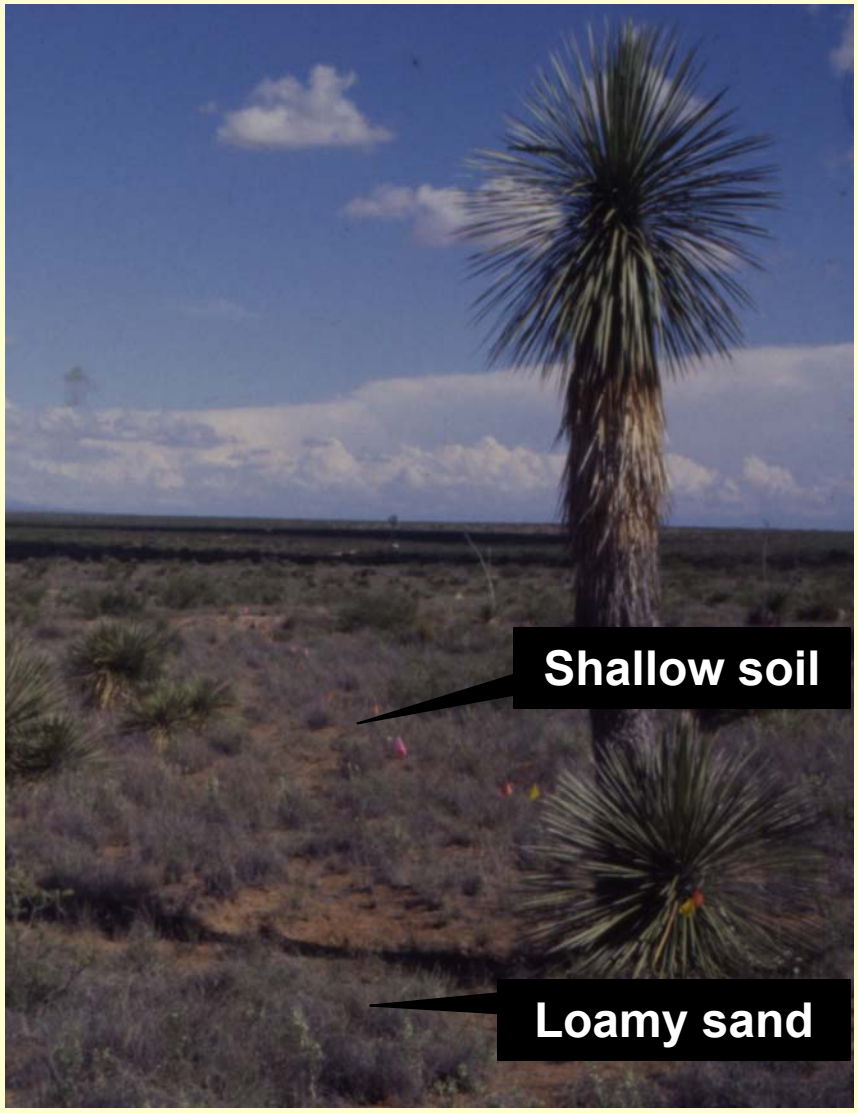
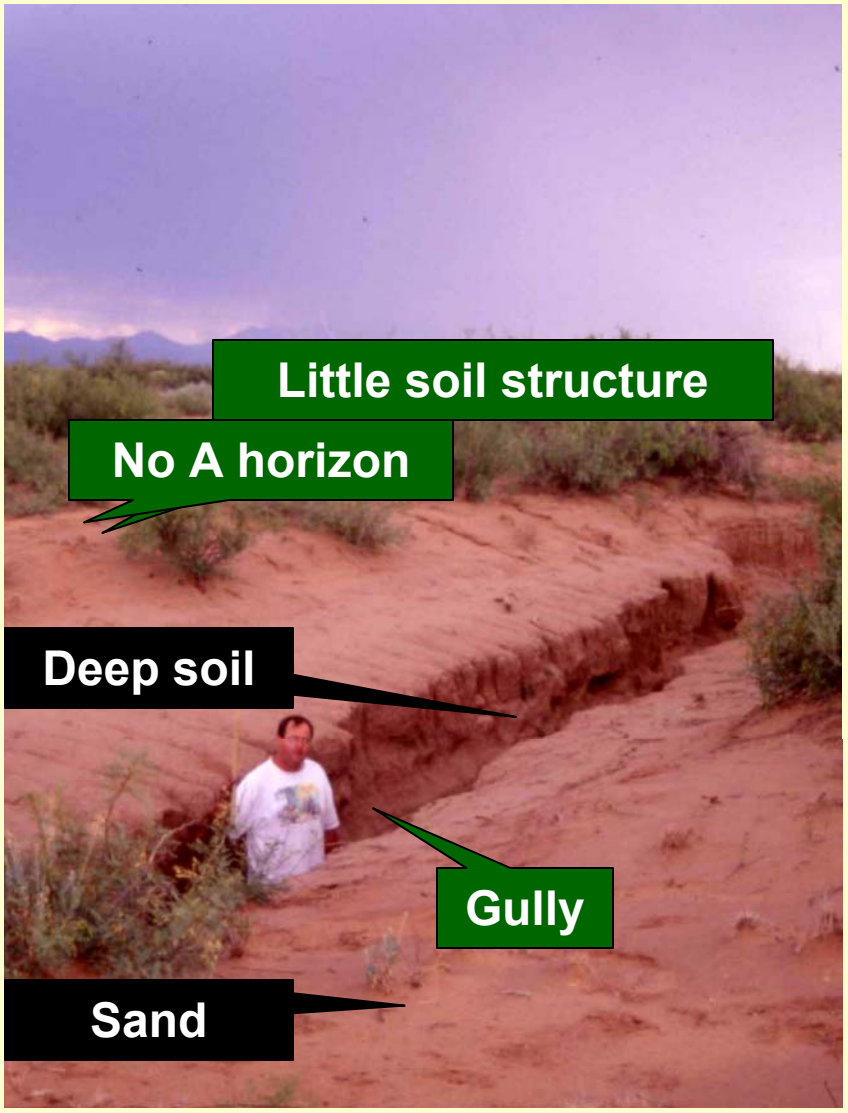
Explorer Game - Brown Level - States





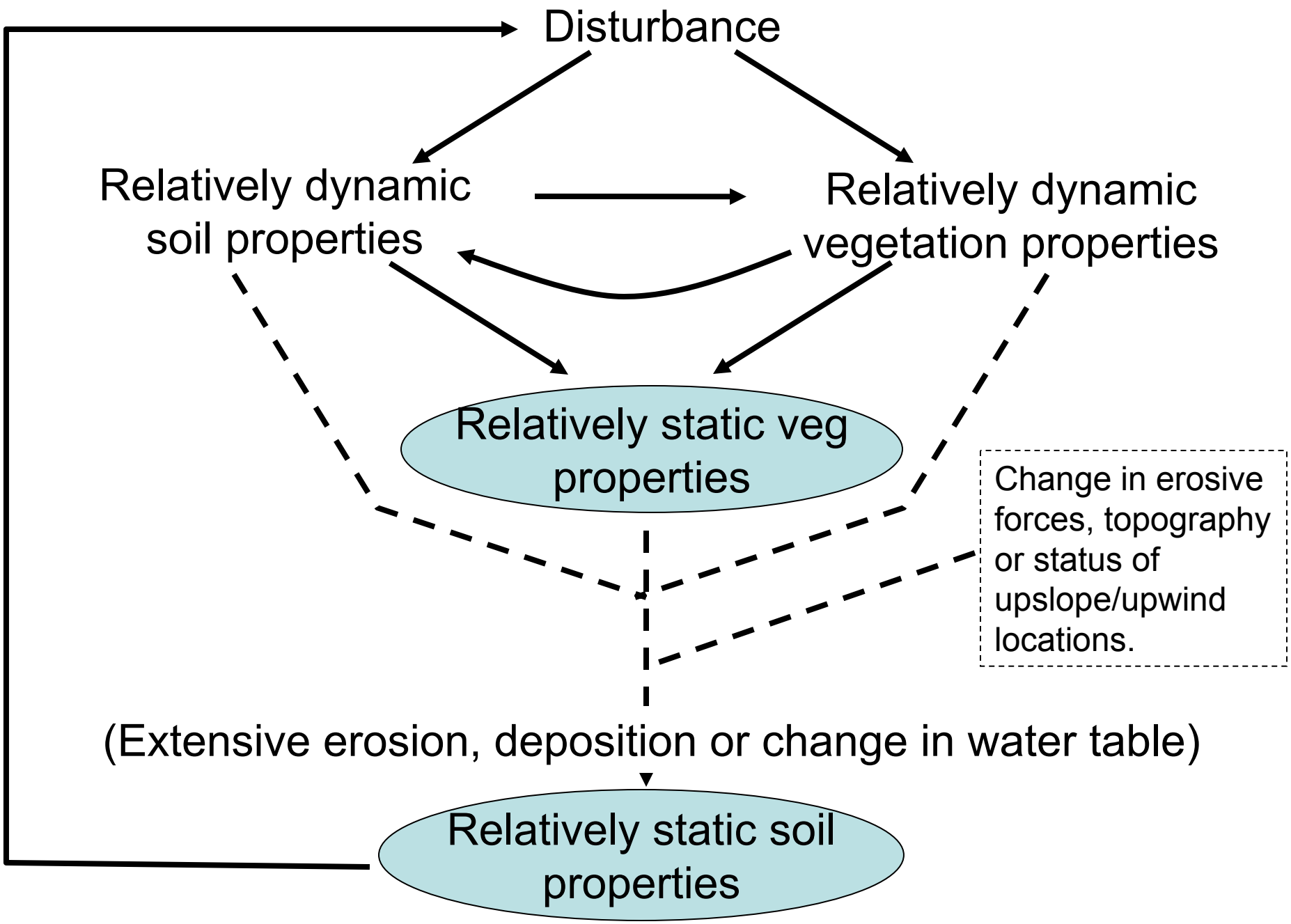
Find 4 differences.

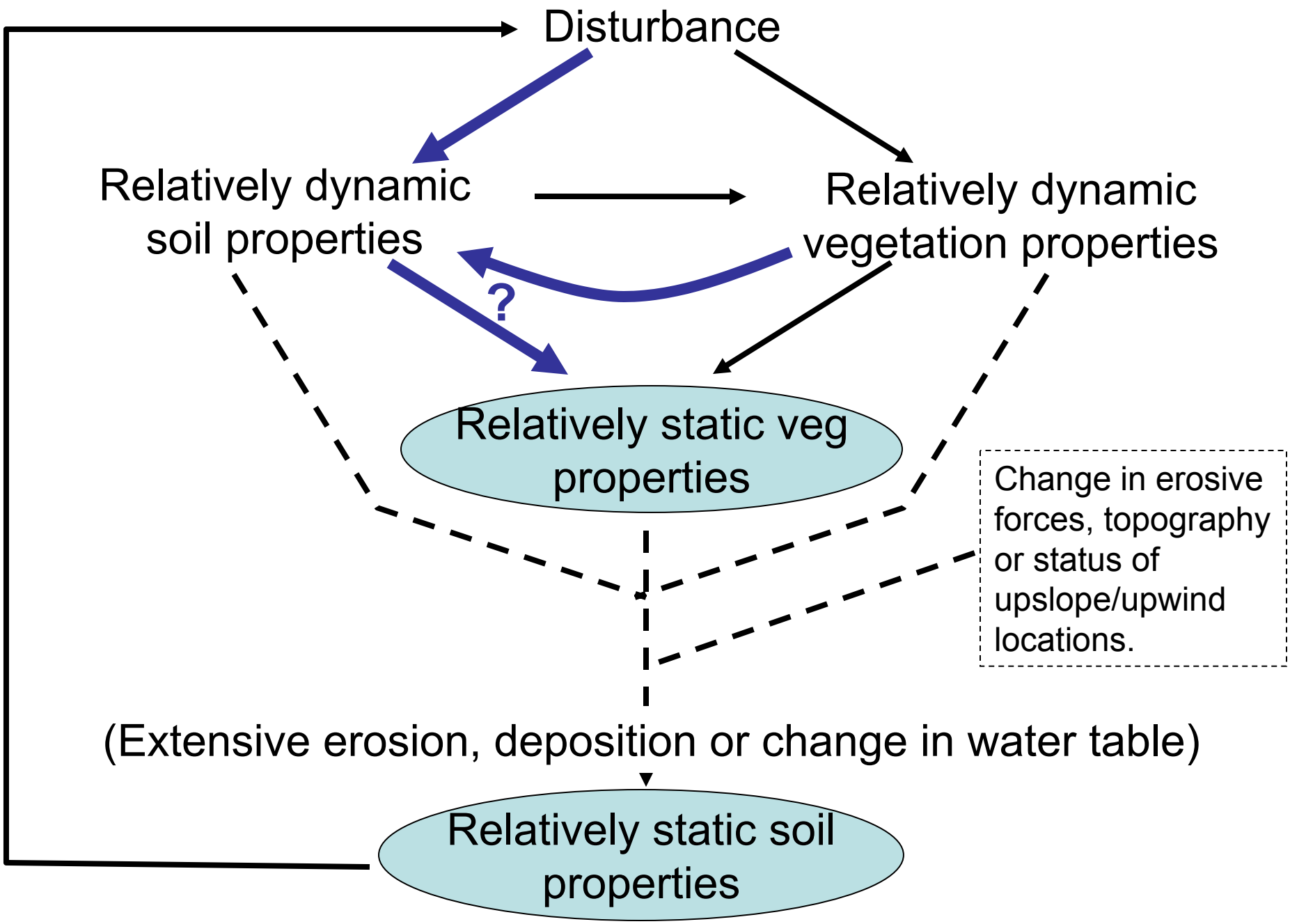
Give up

Relatively "*static*" soil properties *affect* resilience

Relatively "*dynamic*" soil properties both *affect* and *reflect* resilience

	Resilience is	
	***affected* by**	***reflected* by**
Relatively "static"	Slope Aspect Mineralogy Depth Texture	
Relatively "dynamic"	Gullies Structure/water holding SOM (A horizon) Structure/infiltration Rills	


Disturbance
Relatively dynamic soil properties
Relatively dynamic vegetation properties
Relatively static veg properties
Change in erosive forces, topography or status of upslope/upwind locations.
(Extensive erosion, deposition or change in water table)
Relatively static soil properties


Disturbance
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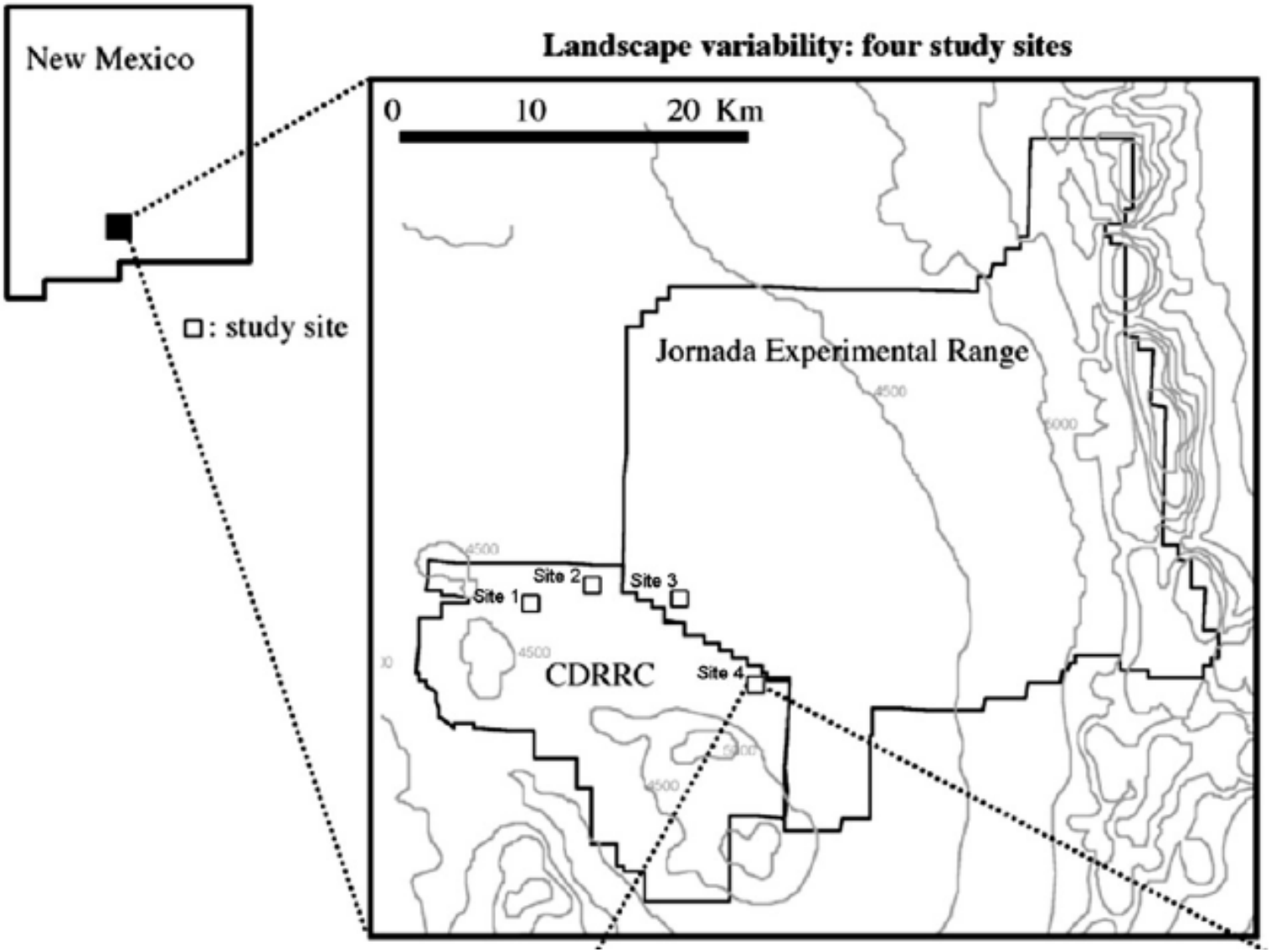
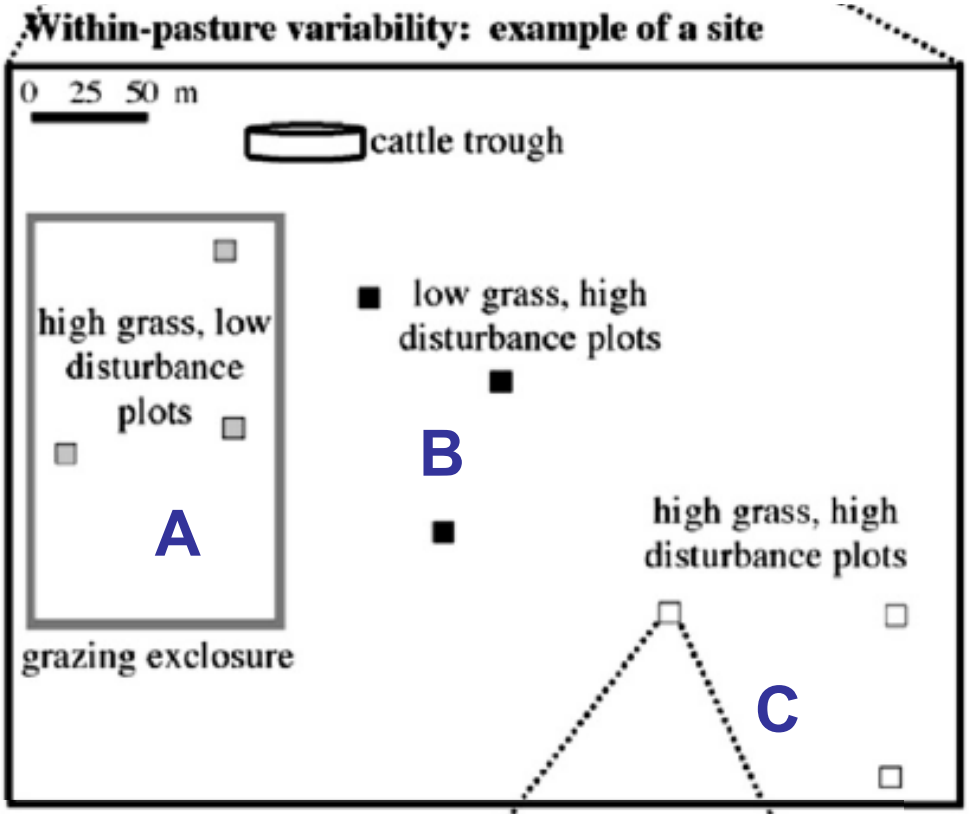
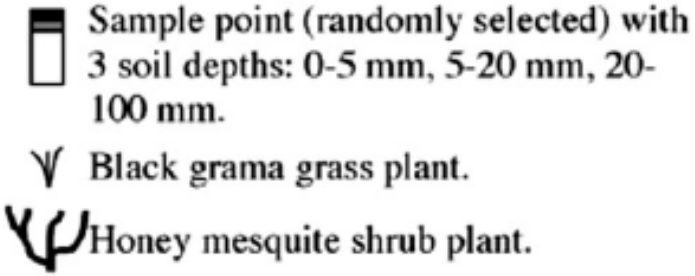
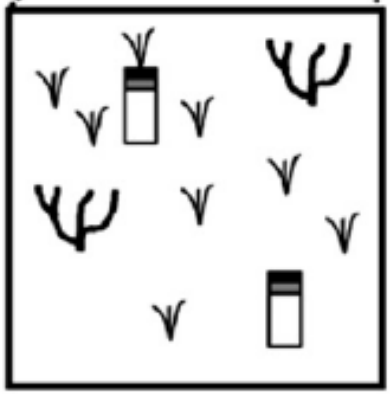

New Mexico
□: study site
Landscape variability: four study sites
0
10
20 Km
Jornada Experimental Range
CDRRC
Site 1
Site 2
Site 3
Site 4
4500
5000

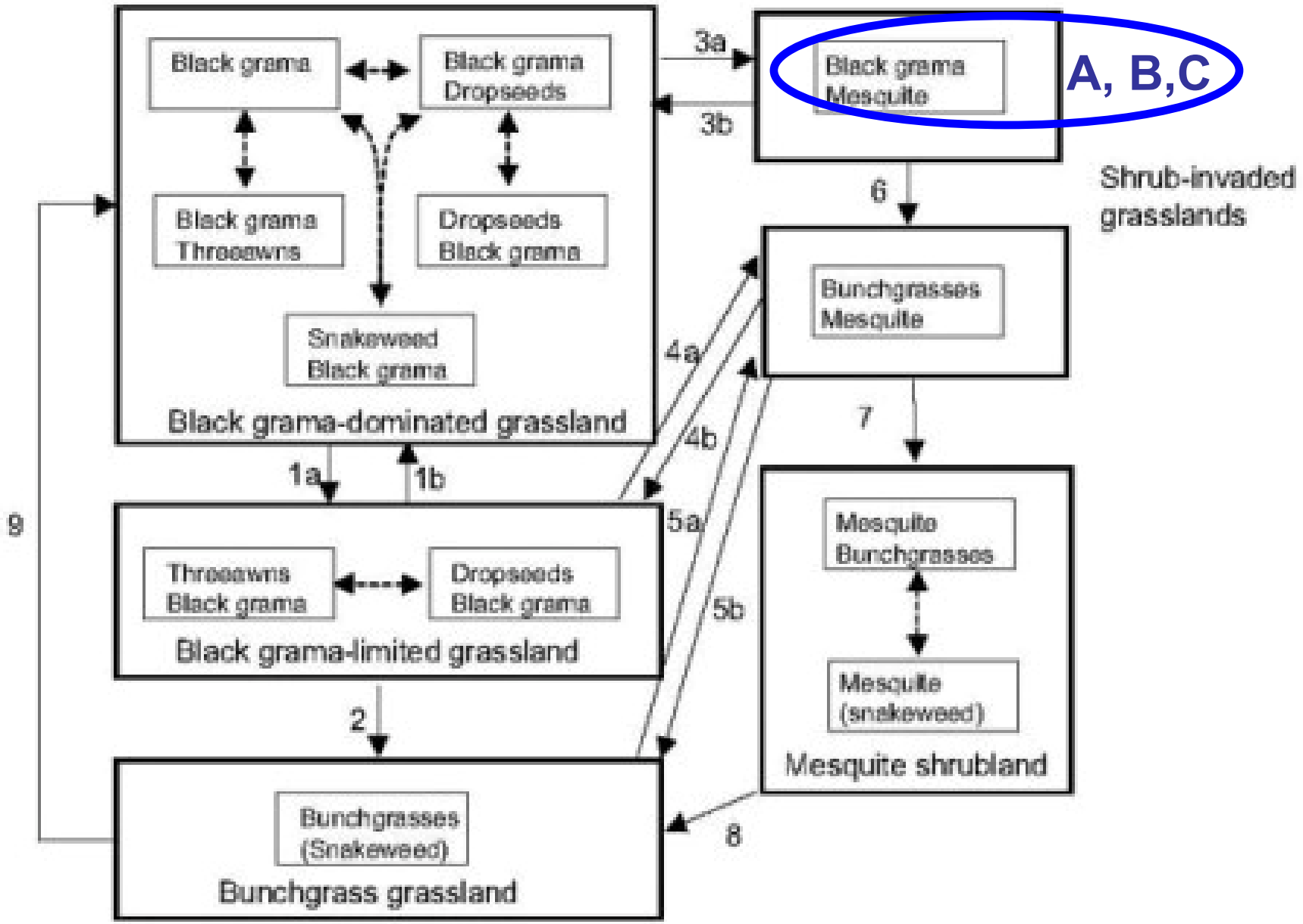


Plant variability: example of a 10 x 10 m plot



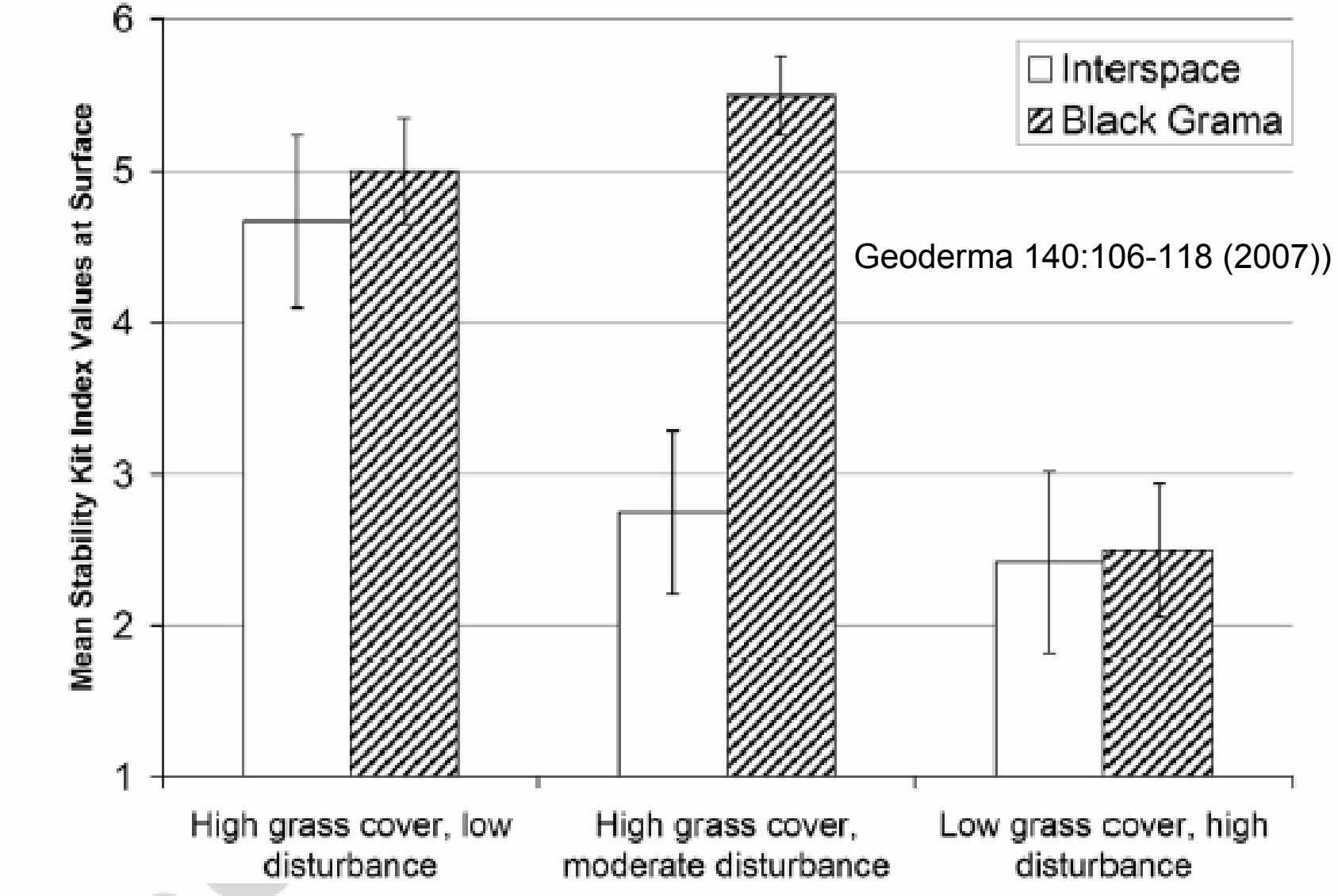


State-Transition model: MLRA 42, SD-2, Upland sandy site group: Sandy



ESIS: R042XB012NM accessed 1/28/08

(% foliar)	A	B	C
Black grama	52	53	9
Mesquite	0.1	1.7	5.8



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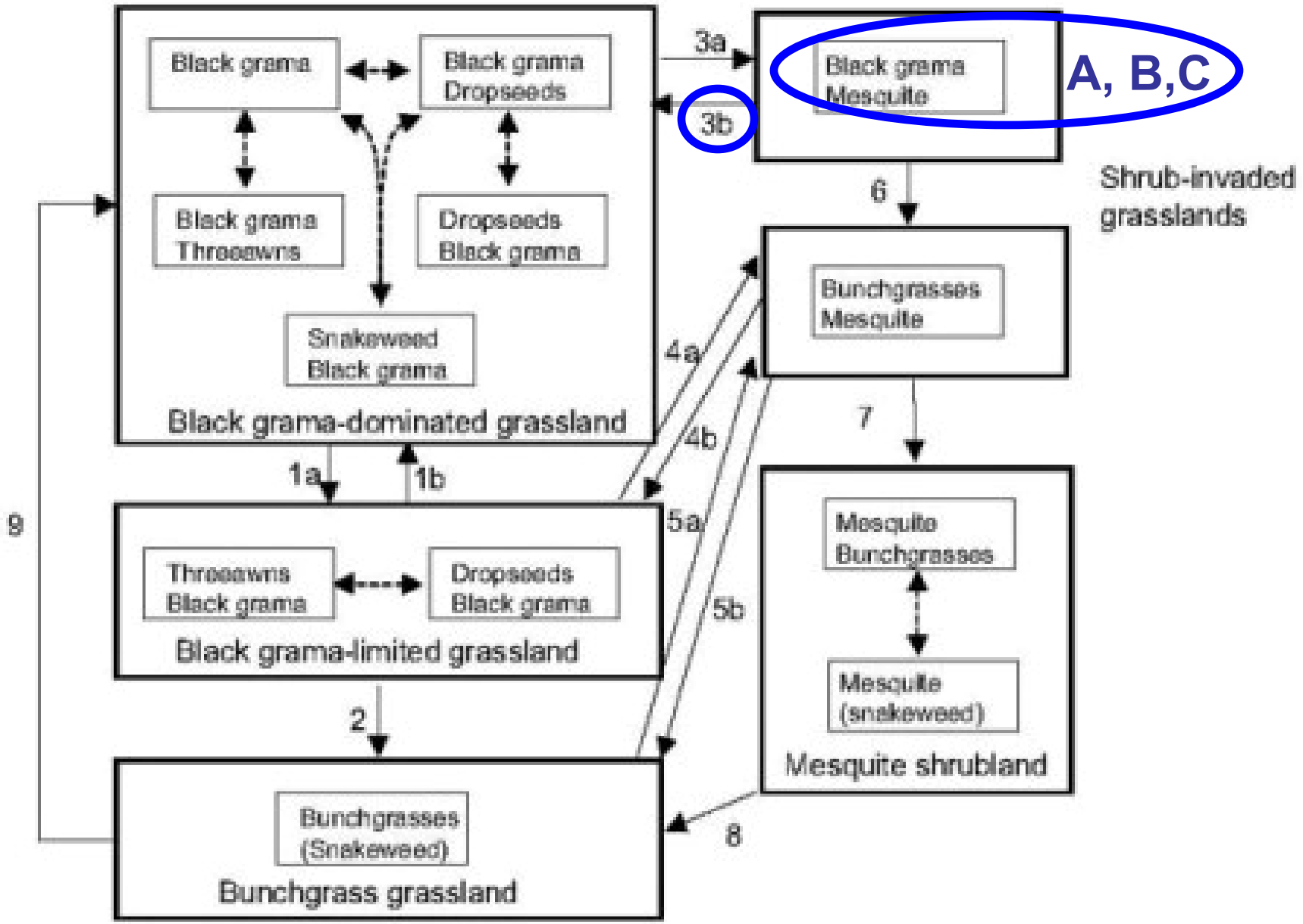

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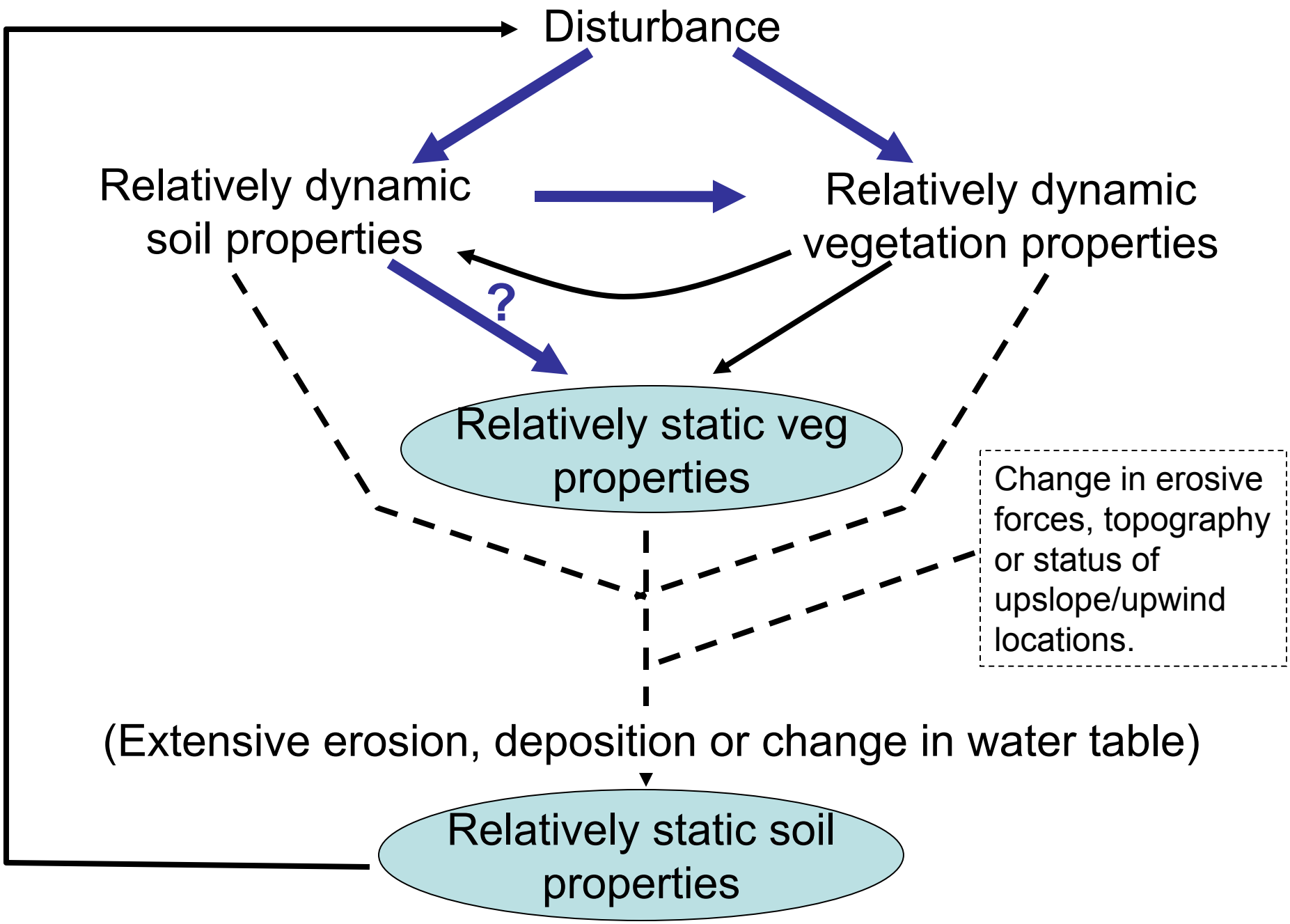
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Relatively dynamic vegetation properties
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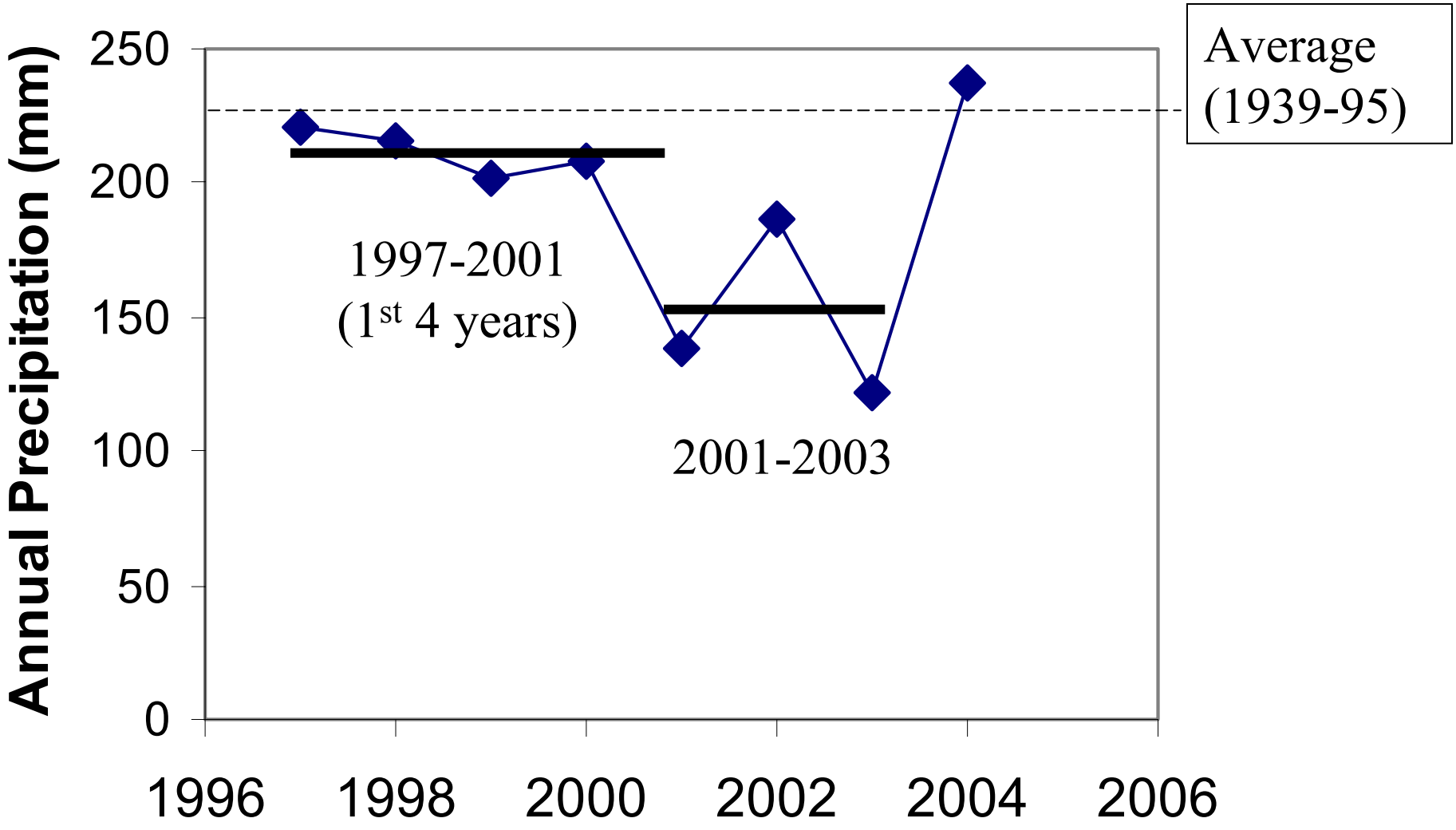
Relatively static soil properties

(2) Resilience

Incomplete recovery: vegetation drought resistance was lower in the degraded plots

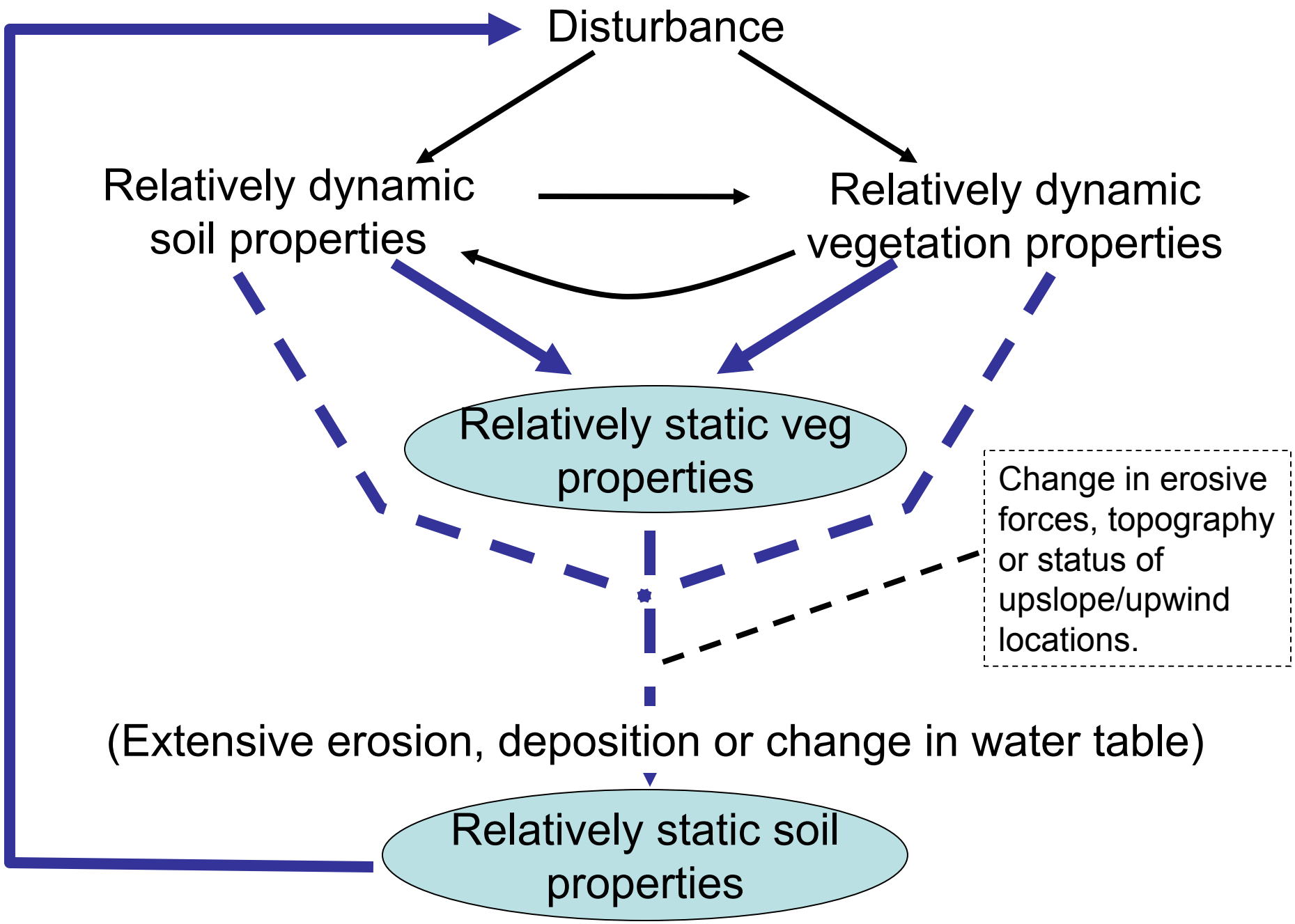

Annual Precipitation (mm)
250
200
150
100
50
0
1996
1998
2000
2002
2004
2006
Average
(1939-95)
1997-2001
(1st 4 years)
2001-2003

Summary

- Changes in dynamic soil properties in response to one disturbance (OHV) can *may* reduce future resilience relative to another type of disturbance (e.g. drought)
- Disturbance response varies with soils and plant communities
- Long-term studies are required to define both patterns and processes

But what happens when relatively static properties become dynamic?

Changes in a relatively static soil property (soil surface texture) generated by a state change in an upwind ecological site may generate soil deposition, triggering soil-plant feedbacks that result in changes in both dynamic soil properties and plant community composition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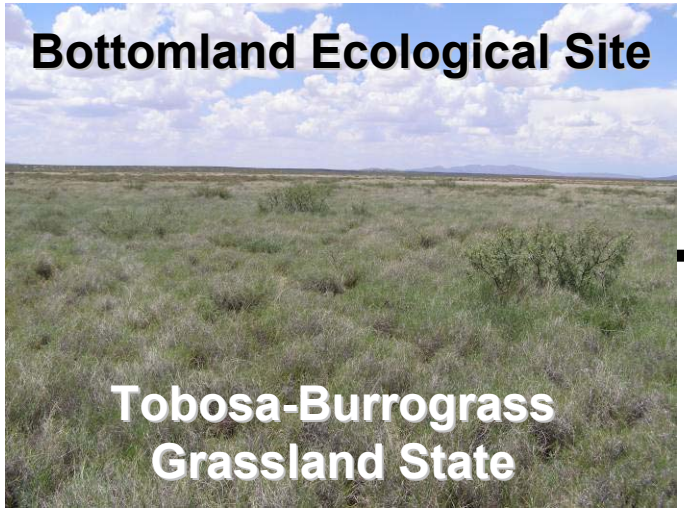
State Changes due to Shrub Invasion (N. Hansen study)

mesquite encroachment

reduction or loss of grassland vegetation

increased soil erosion in interspaces

redeposition of soil into coppice dunes



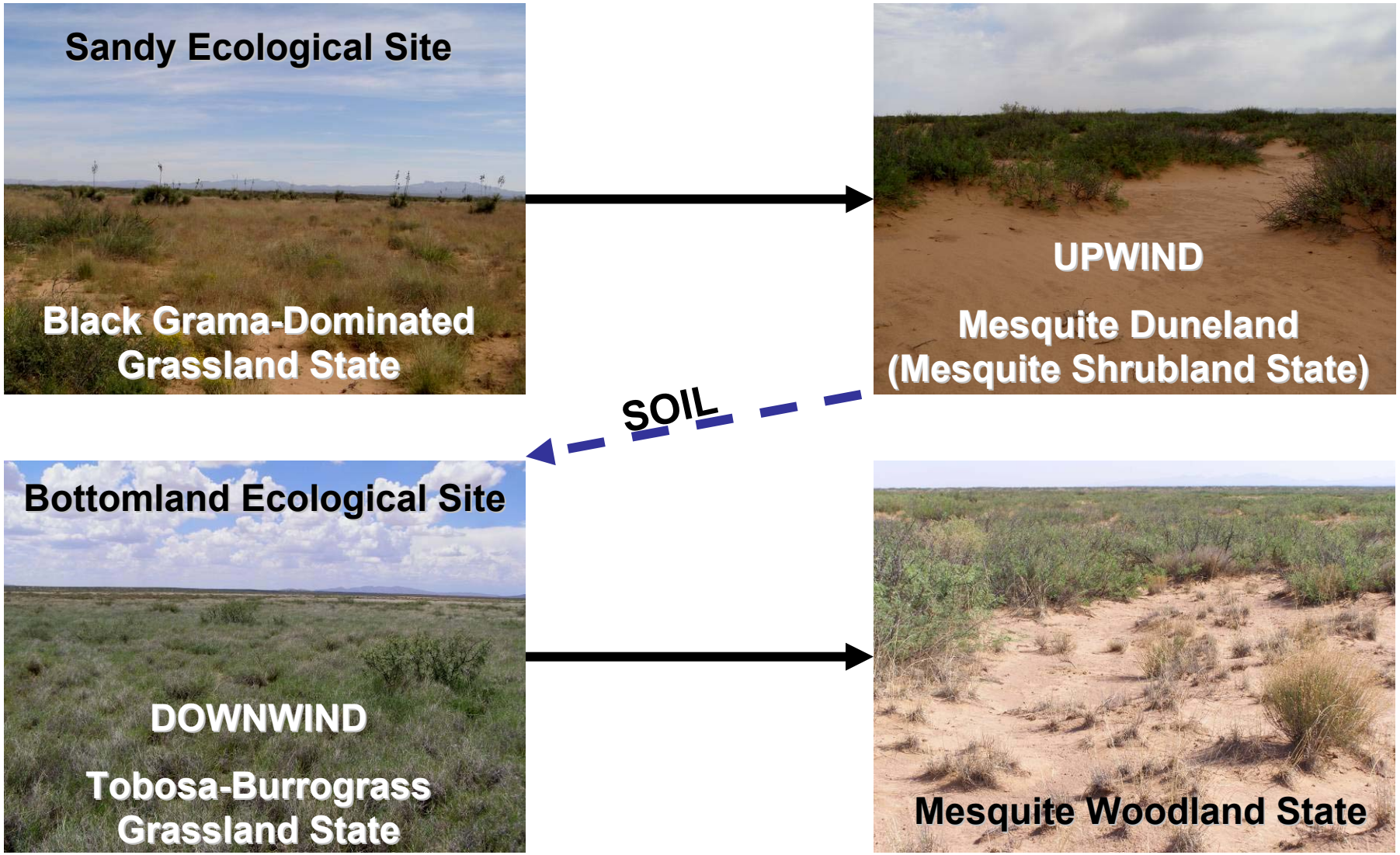
mesquite encroachment

reduction in grassland vegetation

sand deposition over fine-textured grassland soils

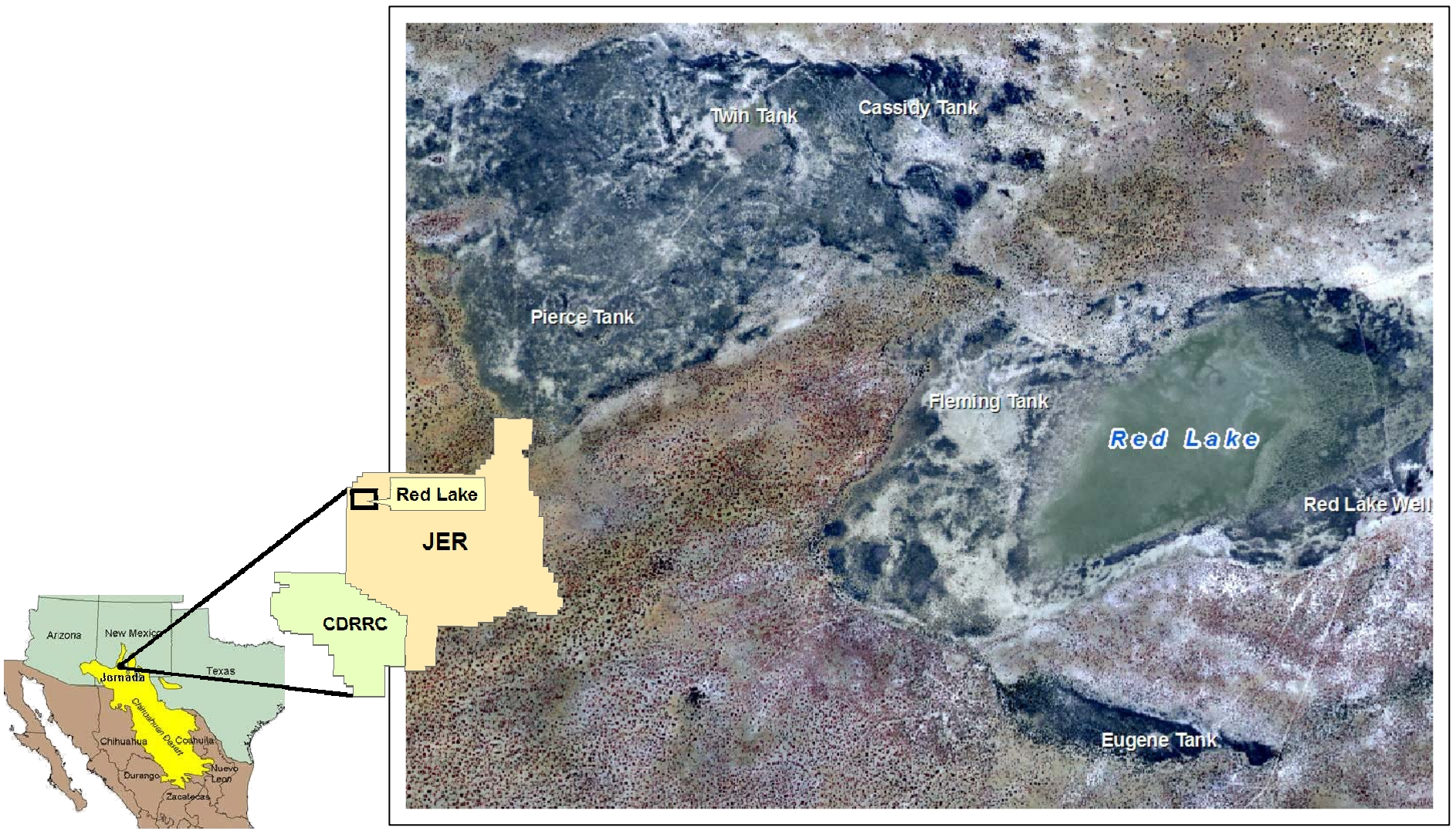
increased erosion

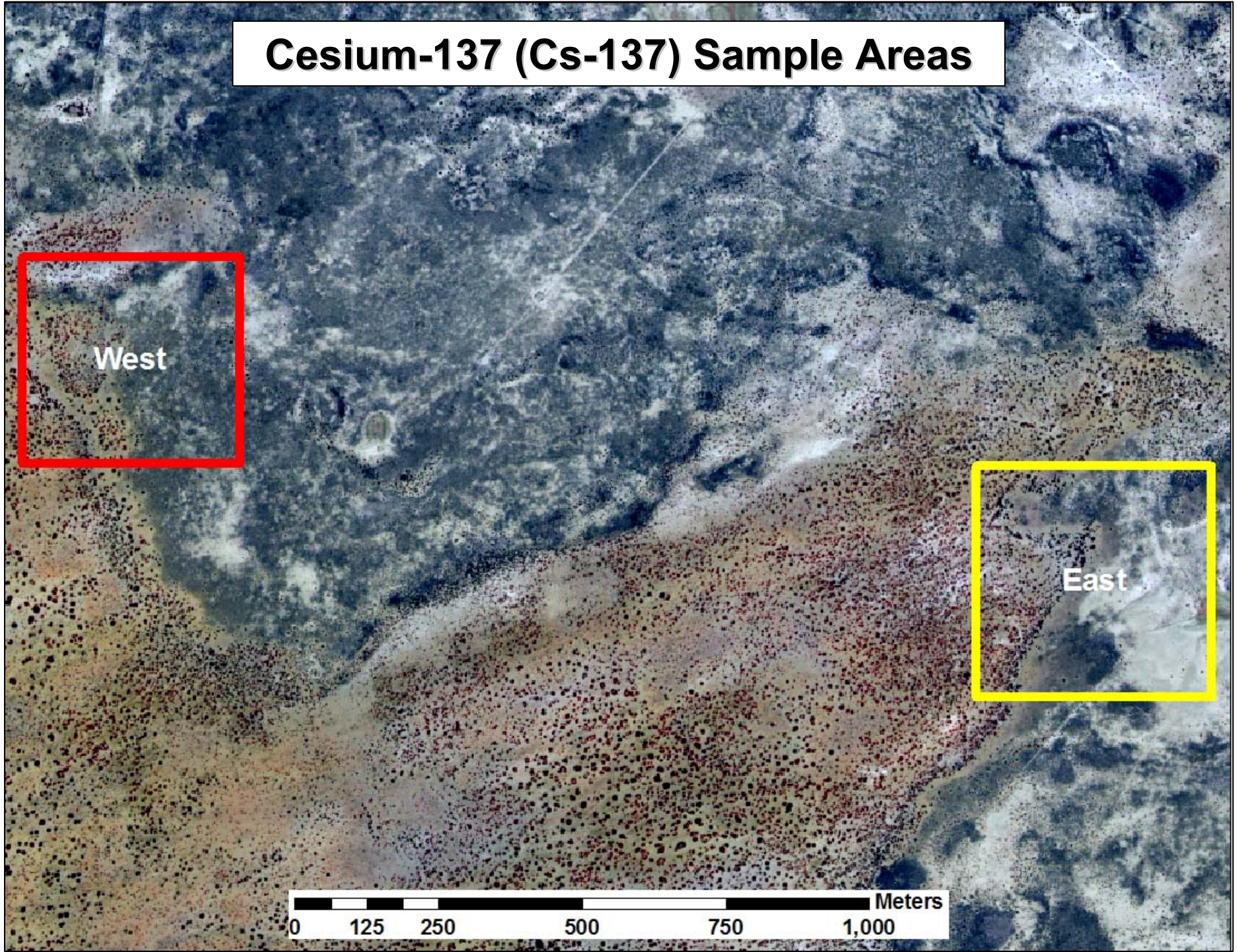
State Changes due to Shrub Invasion (N. Hansen study)



Study Site: Red Lake

USDA-ARS Jornada Experimental Range




Cesium-137 (Cs-137) Sample Areas
West
East
Meters
0
125
250
500
750
1,000

Summary

- Soil accumulation since 1950's in both grass- and mesquite-dominated areas
- Similar or greater accumulation in the mesquite band than grass patches
- General pattern consistent in 2 areas
- Combining with buried A-horizon, historic air photo analyses *may* help determine the extent to which soil deposition affects the resilience of tobosa grasslands (*see N. Hansen's 2008 thesis…)*

Summary: Soil Processes

- Changes in relatively *dynamic* soil properties can change the current resilience of the plant community
- Changes in relatively *static* soil properties can change both current and potential future resilience
- Modeling based on an understanding of soil processes, in addition to space-for-time studies, will be necessary to understand and predict resilience changes.

Implications for Sampling

- *Stratify* with relatively static properties (associated with soil map unit components and ecological sites). Where necessary, sub-divide strata (e.g. plant-interspace or shoulder vs. backslopes).
- *Characterize (1x) "*static" properties, focusing on those that with greatest effects on resilience.
- *Monitor* dynamic properties. Where necessary, sub-divide strata (e.g. plant-interspace or shoulder vs. backslopes).
- CEAP implications: areas that are most susceptible to soil degradation (Δ dynamic properties) or erosion (Δ static properties) are not necessarily the same as those where either degradation or erosion is most likely to change resilience.